WIRELESS SENSOR NETWORK FOR SMART POWER MANAGEMENT

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FOR SMART POWER MANAGEMENT

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"*To my beloved family and friends, thanks for being there throughout this journey*"

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ABSTRACT

Wireless Sensor Network has been widely applied in broad fields in line with current emerging trends, such as automatic control, automated meter reading, power management, etc. Having this system in place provides convenience, increases efficiency and result in well-managed system. The aim of this project is to develop a smart power management system using wireless sensor network. The system is developed by using an unlicensed radio frequency (RF) band where communication takes place between the main controller unit and sensor nodes on the basis of current consumption at every node. Each sensor node will sense current consumption of a dedicated device assigned to it. Data acquisition from the main controller is flexible to operate in round robin or interrupt service routine (ISR) manner. Power consumed by each device which is proportionate to the value measured by the sensor node will be calculated at the main controller and stored in a database within the main controller itself. As many sensor nodes can be placed as possible within the distance range of the main controller (40 meters indoor and 120 meters outdoor line-of-sight). Throughout this project, hardware and software development were done concurrently in order to optimize the time consumption. Validation and verification process includes calibration of current sensor used and experimenting current measurement of several electrical appliances, such as 240V – 12V transformer, electric kettle and hair dryer. Measured device activity can be controlled by placing an electromechanical switch to switch the power ON or OFF.

ABSTRAK

Wireless Sensor Network merupakan aplikasi perhubungan tanpa wayar yang terkenal pada masa kini sejajar dengan perkembangan teknologi yang pesat. Antara contoh aplikasi yang menggunakan teknologi ini termasuklah kawalan automatik, bacaan meter secara automatik, pengurusan kuasa elektrik dan sebagainya. Wujudnya sistem ini dapat memberikan kemudahan, meningkatkan keberkesanan kerja dan menyediakan pengurusan sistem yang teratur. Matlamat projek ini adalah untuk membangunkan sebuah sistem pengurusan kuasa elektrik bersepadu. Sistem komunikasi dibangunkan menggunakan jaringan radio frekuensi (RF) tanpa lesen di mana komunikasi antara unit kawalan utama dan cawangan pengesanan adalah berasaskan penggunaan arus elektrik yang dikesan oleh setiap cawangan tersebut. Penerimaan data oleh unit kawalan utama dari cawangan pengesanan boleh dilakukan secara *round robin* ataupun *interrupt service routine (ISR)*. Pengiraan arus dan kuasa elektrik yang berkadaran dengan nilai yang diterima dilakukan oleh unit kawalan utama dan seterusnya disimpan di pangkalan data unit kawalan itu sendiri. Unit ini mampu berkomunikasi dengan sebanyak mana cawangan pengesanan yang ada selagi jaraknya adalah dalam lingkungan 40 meter bagi kawasan tertutup dan 120 meter di kawasan terbuka tanpa halangan. Pembangunan perisian dan peranti elektronik sistem dilakukan secara serentak untuk mengoptimumkan masa yang diambil bagi melengkapkan projek. Antara langkah-langkah penentusahan sistem yang diambil termasuk penyenggaraan peranti pengesan arus yang digunakan dan ujikaji pengukuran arus beberapa perkakasan elektrik seperti alat pengubah voltan 240V-12V, cerek elektrik dan pengering rambut. Kebolehkawalan boleh diwujudkan dengan menyambungkan suis elektromekanikal kepada sistem ini.

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LIST OF ABBREVIATIONS

ADC	-	Analog-to-Digital Converter
ADRESL	-	Address Low Register
ADRESH	-	Address High Register
API	-	Application Programming Interface
GEAR	-	Geographic and Energy Aware Routing
GUI	-	Graphical User Interface
IC	-	Integrated Chip
I/O	-	Input / Output
ISM	-	Industrial, Scientific and Medical
ISR	-	Interrupt Service Routine
LOS	-	Line-of-Sight
MAC	-	Medium Access Layer
OSI	-	Open System Interconnection Reference
PC	-	Personal Computer
PHY	-	Physical Layer
RAM	-	Random Access Memory
RF	-	Radio Frequency
UART	-	Universal Asynchronous Receiver / Transmitter
USART	-	Universal Synchronous / Asynchronous Receiver / Transmitter
USB	-	Universal Serial Bus
VB .NET	-	Visual Basic .NET
WAMR	-	Wireless Automated Meter Reading
WSN	-	Wireless Sensor Network

CHAPTER 1

INTRODUCTION

1.1 Introduction

It is expected that in future, the demand for energy will escalate and this will require either new source of energy or new power plant constructions. And the cost of providing power is also increasing due to higher fuel prices and increases in the cost of construction and capital expenses. People are even now investigating other natural sources as new energy sources of power plant such as coal, wind, solar and fuel cells to ensure that global energy supply could be increased and maintained.

However, one important basic way of preserving the energy supply that has been ignored by the researchers is the management of power distribution. This is a very important subject in the area of energy conservation. Wireless sensor network (WSN) can be greatly utilized in the area of demand-side management. It can slow down or decrease maximum energy consumption to increase energy efficiency. One way of realizing it is by setting the system to monitor and control low power and high power usage devices in its coverage area.

In the case of excessive demand of electrical supply, some basic appliances are critically in need of power and should be allowed to operate. A system that can differentiate between high power and low power usage can be created at every sensor node and allows only low power devices to be ON for that particular period.

This is where WSN comes in. By controlling the appliances with minimum anticipation of users, it can greatly improve energy efficiency and utilities by creating load management. Wireless communication protocol is used to realize this system. WSN is a collection of wireless nodes with sensing capabilities, which is distributed in a bounded area and is used to monitor either physical or environmental conditions. These nodes can communicate with one another and use each other as a path through the network in order to communicate with a controller or even a gateway.

One obvious advantage this system has over the existing conventional wired systems is the last-mile connectivity. In term of advantages WSN can offer above all other wireless sensor network is that it offers power management for multiple industries, wireless automated meter reading (WAMR) and electric systems monitoring.

This project is focusing on developing a power management system using WSN. It consists of a microcontroller, a standard wireless module as well as sensing elements that can communicate wirelessly with the control unit for monitoring. The communication is in full duplex mode. The communication will consist of data transfer that controls the node operations. PIC16F microcontroller is used as the controller at each node, XBee series 2 module (with ZigBee protocol) is chosen as the wireless protocol, Hall-effect sensor from Honeywell Inc. is used as a sensing element at each sensing node.

The advantage of using this PIC16F is that it is a 8-bit microcontroller that provides extra features that do not require major changes of pin configuration when future works is to be done, apart being the most common and widely used microcontroller. As for XBee, the main advantage is that it requires very less amount of power so it can be operated from battery. Power consumption has been of interest for WSN since the system is required to endure as long as possible with small power consumption. So, choosing the XBee as wireless protocol is believed to be the best choice.

1.2 Problem Statements

There are three problem statements carried out of this project:

1. Having automated power management system will make efficient energy consumption, speed and reduced personnel intervention in making decision and most importantly monitoring the activity at the sensing nodes.
2. For intelligent house application, the main controller can optimize the use of electrical energy throughout the house by wireless sensor network which will provide information of energy consumption for each part of the house. Conventional houses do not apply this.
3. In most housing areas, meter reading is still done manually. Having wireless automated meter reading implemented in place will reduce operational costs for power supply companies.

1.3 Objectives

There are three objectives of this project:

1. The main controller in the wireless sensor network using unlicensed frequency will identify and monitor current flow activity at each sensing node to make the efficient use of power.
2. This project also strives at understanding current measurement in sensor nodes. Power consumed in the network can be calculated depending on the implementation of the WSN.
3. To design and build an efficient sensor node that will automatically measure current flow of a particular device, so that it can make efficient power management.

1.4 Scope of Project

This project consists of two parts that are the sensing node and the main controller unit. As shown in Figure 1.1, a group of application devices are connected to a main controller which monitors the activity of measured parameters at each sensing node. In the sensing node part, it has several functioning devices such as hall-effect current sensor, microcontroller and the X-Bee series 2 RF module (acts as transmitter and receiver). The controller unit consists of X-Bee series 2 RF module (also acts as transmitter and receiver), serial interface board, personal computer with Visual Basic.Net (VB.NET) program and MySQL database.

The idea of this project is to implement wireless protocol communication using Zigbee wireless protocol which applies unlicensed frequency band of 2.4GHz in wireless sensor network by using radio frequency (RF) module namely XBee

series 2 RF module. Current measurement in assigned devices is done by Hall-Effect current sensor placed in the sensor node. The measurement data will then be injected into the PIC microcontroller for monitoring purpose. The microcontroller will process the data and transmit it to the main controller wirelessly via transceiver XBee series 2 RF module. However, measurement request must initially come from the main controller unit. Upon receiving the response data from a particular sensor node via another transceiver XBee series 2 RF module, manipulation of data will take place using Visual Basic .NET and the data is then stored in MySQL database.

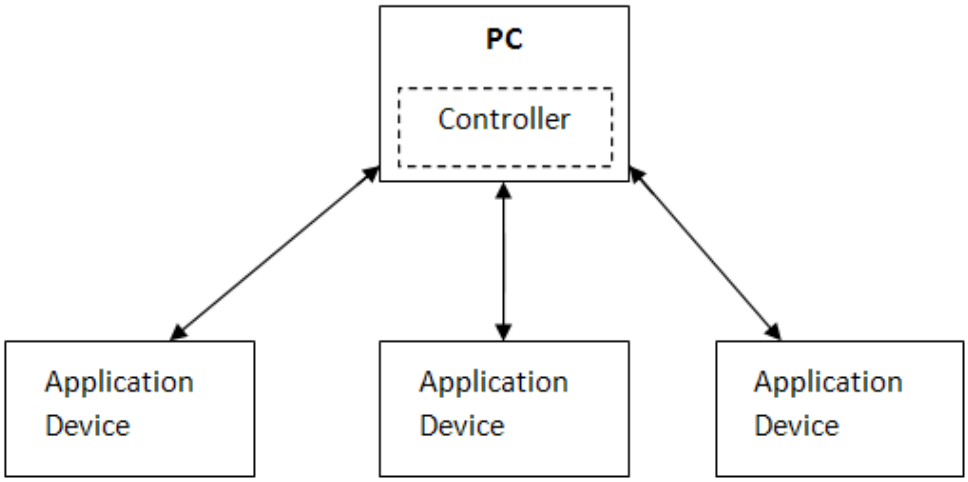

Figure 1.1: General system diagram

Figure 1.2 below shows the functional block diagram of the whole system. This system is designed to operate in half duplex mode. It initially starts from the request made by the control unit to a dedicated sensor node. The dedicated sensor node will then respond to the request and transmits requested data to the main controller unit. The XBee RF module transmits data in 2.4GHz unlicensed frequency band.

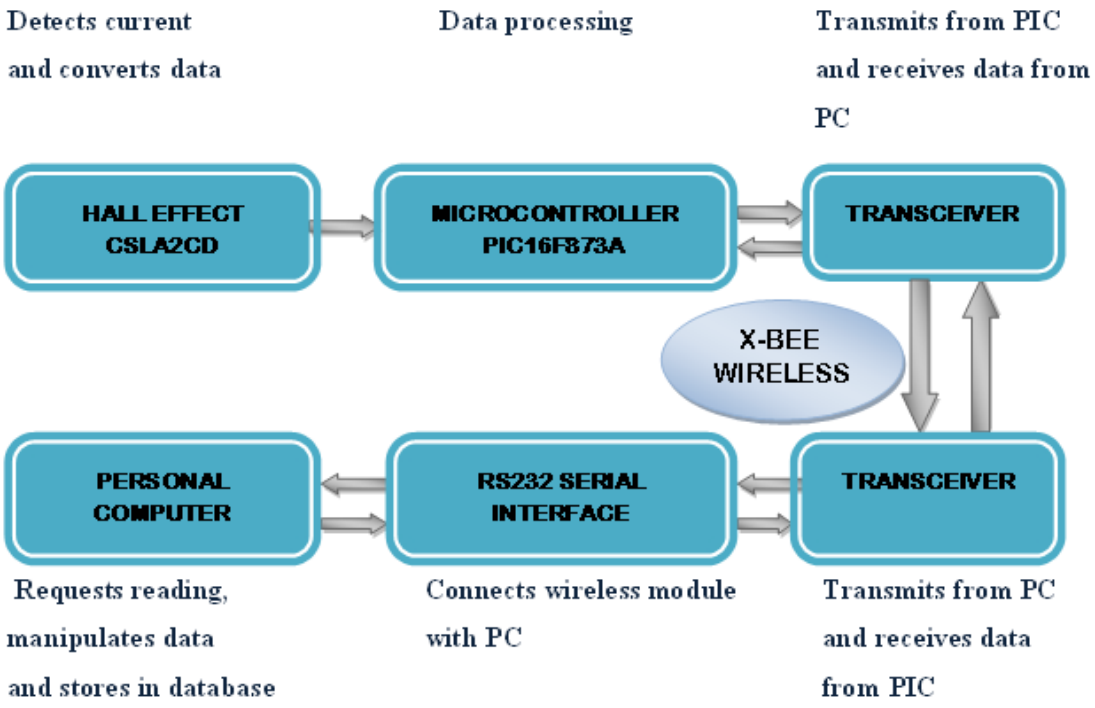

Figure 1.2: Functional block diagram

1.5 Sensor Node Features

The sensor nodes in this system will make a fast, reliable current measurement. With the mobility of the sensor within the indoor range of 40m and outdoor line-of-sight of 120m, and operating at 2.4 GHz wireless frequency band, many applications can be measured. It is also very suitable for intelligent house application where the use of current inside the house can be monitored and controlled. The sensor applied uses no complex circuitry except for high current and high voltage purposes. Also, it provides linear output when current is sensed through its hole.

1.5.1 Wireless Sensor Network for Smart Power Management System Specifications

Remote function: Senses current when requested by control unit and transmits measurement to control unit wirelessly via Zigbee protocol.

- Frequency: 2.4 GHz
- Range:
- Indoor/urban: up to 100 feet (40m)
- Outdoor: up to 300 feet (100m)
- Operating voltage:
- PIC microcontroller: 5V
- XBee series 2 RF module: 3.3V
- Hall-Effect current sensor: 6 – 12V
- Power: 6.5V batteries
- Transmit power: 2mW (+3dBm)
- Receiver sensitivity: -96dBm
- Data rate: 2500 bit per second (bps)
- Interface: Serial communication
- Graphical user interface (GUI): VB .NET
- Database: MySQL

1.5.2 System Requirements

- Microsoft Visual Basic 6.0 .NET
- Windows 98,2000,ME,XP
- Serial Communication

- MySQL database
- X-CTU software

1.6 Outline of Final Report

This final report consists of five (5) chapters. The first chapter describes the background of the related issue on power management, problem statements, objectives scope of project, project specification and requirements. The second chapter will cover about the background of remote control, literature review as well as wireless sensor network for smart power management application available in the market. The third chapter consists of the theory about the software and hardware implemented in this project. The main points to be discussed in this chapter are the methodology of this project. Two major parts will be looked into, that are software development and hardware development. Chapter four will discuss on the results obtained as well as general discussion on the result. Problems occurred throughout the project will also be discussed. The last chapter is about the summary and conclusion of the project. In this chapter, future work will also be suggested for the benefits of research and development of this power management using wireless sensor network.

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